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ABSTRACT

This article discusses past research on the hemispheric process of the brain, proposes an educational perspective based on this research, and lists several areas for interdisciplinary study of the relationship between education and the psychobiological dimensions of learning and learning problems. In developing an educational perspective of the hemispheric brain process, three elements are identified: the historic recognition of the two modes of intelligence; consideration of the physiological dimensions of learning behavior; and hemispheric brain functioning research, particularly the techniques of dichotic listening, tachistoscopic presentation time, and electroencephalographic measurement. The article lists six areas of educational research that require an emphasis on hemispheric brain process: reduction of measurement error in educational assessment, task analysis, instructional assessment, interaction and communication, learning problems. and individual ability. An extensive bibliography accompanies the article. (HAI)

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An Educational Perspective on the Hemispheric Process of the Brain

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Overview

"We have finally learned a fact about the brain which is directly relevant to pedagogical practice...It is, most simply, that the brain is double, in the sense that each cerebral hemisphere is capable of functioning idependently, each in a manner different from the other." (Bogen, 1975, p. 24) For well lateralized right handers the modality most characterisitc of the left hemisphere is to process experience analytically, part-by-part and in sequence; while the right hemisphere typically processes experiences in a more intuitive modality characterized by simultaneity, patterning, holism and sensing relations between parts. From the study of brain lesion, hemisperectomy and section of the corpus callosum and the behavior of the normal person"...it is possible to draw three overall conclusions. The first is that the two brain interpretation is valid for...the nervous system of man. Secondly, that the bilateral arrangement allows the total productive capacity of the brain to be increased. Third, that the hemispheres do not work in an all or none fashion, but take part in a highly integrated fusion of functions which is mediated largely by the transporting action of the corpus callosum." (Dimond, 1972, p. 193)

The analytic style is extremely efficient for dealing with the object world. American technology and scientific achievements are well serviced by linear, analytic methods. The holistic mode is good

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for bridging gaps while the analytic process is not. In this complex, imperfect and rapidly changing world, the information available to us id frequently imcomplete. Thus we badly need to develop the ability to "see the big picture" when parts are missing and to sense patterns in out experiences, as well as to build analytic skills. (Galin, 1975)

The interaction between these two processing systems is complex and not fully understood. However, the fact is known that the human nervous system has both inhibitory and facilitatory functions (Hilgard and Bower, 1975) which enables the hemispheres to exhibit complimentary functioning when the hemispheres work integratively (Bogen and Bogen, 1969); selective complimentary functioning, when one hemisphere selectively uses sybsystems of the other to solve a problem (Vogel, 1966; Broadbent, 1974); parallel functioning, when each hemisphere works independently on a problem which may later be integrated (Dimond, 1972; Dimond and Beaumont, 1974); independent functioning, when one hemishpere inhibits the other to solve the problem (Galin, 1974); and conflicting functioning, when each hemisphere works alone on the problem and is in conflict with the other in terms of the solution (Galin, 1974).

Therefore, the concern of educators with the brain's dual capacity is simple and clear. What are the educational consequences of various interactive patterns between and within the hemispheres - complementary, parallel, independent and conflicting? Smooth functional integration of hemispheric modalities would seem to be a desired goal in many educational experiences. At other times educational task

requirements and individual variation in cognitive style propensities may be most effectively served by other hemispheric interaction patterns. Finally, stress and problems of learning may result from neurological conflict (e.g., between hemispheric structures) some of which may be induced by pedagogical procedures and curricular emphases.

Emerging from the simply stated fact regarding brain functioning is a broadly based growing recognition in the educational community of a promising and provocative new field: educational applications of hemispheric processes of the brain. (UCLA Educator, 1975; Ornstein and Galin, 1975; Languis and Draft, 1976) There is a rapid increase in national attention on the subject and a substantial body of professional and research literature is accumulating. The first national conference on educational applications of hemispheric brain process was scheduled in February, 1976.

This article has two purposes: first, to examine three elements comprising the perspective of hemispheric brain processes for educators, and second, to propose six directions for research relating educational concerns to the hemispheric brain process.

Perspective: The Hemispheric Process of the Brain and Education

A contextual framework must be recognized. The focus of this article is upon the hemispheric processes of the brain; but the cerebral hemispheres do not function in isolation. While the cerebral cortex operates roughly at the top of the neural "chain of command" hierarchy, there is an enormously complex interacting sympathetic and

autonomic neural, endocrine and physiological network in which the hemispheres participate. (Thompson, 1975) Moreover the hemispheres of the brain function within the human organism whose psychological make-up and psychosocial history actively interact in neural processing of present experience. (Corson, 1976) Therefore, in any serious study relating hemispheric function and learning, and especially in applying the psychobiology of behavior to the educational milieu, it is crucial to recognize this broader perspective and to utilize an integrated model of the human organism in interpreting findings.

Now that we have defined the emphasis of this article within the larger context of interdisciplinary considerations, we shall turn to an analysis of the perspective of hemispheric brain function for education. The perspective will be analyzed in three parts: historical insights into man's mentality, physiological dimensions of learning, behavior and hemispheric brain functioning research using three techniques relevant for education.

1. Historical Insights Into Man's Mentality

A very reasonable question to ask is this: what is of interest to thoughtful educators in the hemispheric processes of the brain? It is abundantly clear to sensitive classroom teachers that no matter what the constraints of a school task, children approach the task in different ways. Teachers know that individual differences undeniably exist in the style children utilize to solve problems. In what seems to be the predisposition of people to conceptualize "compartmentally,"

these differences are often described in dichotomies. One child seems "to have an intuitive grasp of things" and another is much more analytical in his approach to the same task. "He goes about his work in an organized step-by-step approach." For such educators, the specialization in the processing modality of the right and left cerebral hemispheres provides a good intuitive match with observations of children at work in the classroom.

However, if the association were limited to an identification syndrome between classroom practitioners and brain researchers, one might criticize the idea as another simplistic dichotomy, or another "band wagon" movement. There is, however, a much deeper base for the association between conceptualization of man's ways of knowing and man's double brain capacity.

Respected scholars have for centuries recognized two modes of intelligence, two styles of cognition, two ways of knowing. A representative set of these expressions is presented in Table One, p. 15. The persuasiveness of this aspect of the rationale rests in several facts. The persons postulating two major modes of knowing are individuals of considerable stature whose scholarly expressions have amply stood the test of time. Moreover, current educational leaders continue to utilize the same conceptual structure. (Bruner, 1965; Piaget, 1973) In addition, even the most skeptical analysis of the dichotomies they proposed supports the interpretation that there is substantial commonality in them. That is, these writers seemed to have sensed

essentially the same basic capacities in the human intellect. But Ornstein and Galin (1975) caution against "dichotomania" - the casual and excessive application of a host of polar opposites to the duality of the human brain. Severe critical analysis of these claimed associations should preceed utilizing the criteria of hemispheric process modality and interaction patterns between the hemispheres (vs. a static and descriptive phrenology) as referents. This approach will help replace the "either-or" interpretation of dichotic pairs with a more interactive view of man's mental dualism.

Finally, past attempts to educe man's ways of knowing has been basically a "closed box" approach. Inferences drawn from behavioral outputs associated with specific inputs. By contrast, research in the hemispheric process of the brain is a more "open box" approach. For example, consequences of surgically disconnecting the hemispheres of epileptic patients and anesthetizing a hemisphere in normal subjects has been directly studied. The degree of congruence between current brain research findings and the wisdom of the centuries lends support to continued exploration of educational applications of hemispheric brain process.

2. Physiological Dimensions of Learning Behavior

The second aspect in the educational perspective on hemispheric brain process approaches the area from a biological point of view. Stated simply, there is necessarily neural and physiological activity associated with learning. "Nothing is more certain than that our

behavior is the product of our nervous system." (Hilgard and Bower, 1975) The crucial question is the relevance of the statement that as learning occurs there is activity and change in the brain. Measurement of these physiological and neural events in mechanisms of learning, and the hemispheric process of the brain in particular, provides the opportunity to correlate existing educational measures with relevant neurophysiological events and thus reduce measurement error, to build more adequate and reliable theories of learning, to assess more precisely the nature of learning that has occurred, to more adequately diagnose problems in learning, and to evaluate effectiveness of our attempts to facilitate learning. (Rentel, 1975) In the past, it is very clear that we have given virtually no attention to what is happening in the brain and in the body as a student interacts with the learning environment. Educational literature is replete with references to the "whole child" and to "learning with connections." Current directions in brain research provide an opportunity to build a more comprehensive base for facilitating learning in children. It seems reasonable to conclude that educational applications of hemispheric process of the brain is an appropriate goal; but it will require a long range program of interdisciplinary research.

3. Hemispheric Brain Functioning Research Using Three Techniques Relevant to Education

The third aspect of the perspective lies in the educational relevance of accumulating empirical evidence from neurological studies of the brain. Comprehensive reviews of hemispheric brain research findings

have been published elsewhere. The view supported here, consistent with current insights into hemispheric brain fu tion, is a middle of the road approach. The brain is viewed as a bilateral system in which the interplay of the differences in function become of special interest. "It asserts that while both hemispheres play a qualitative role, the contribution of one may be more important than the contribution of the other in respect to certain performances. At the same time weight must be given to the interplay between one hemisphere and the other and the integration of functions each within the performance of the other. This is envisaged largely as a cross-switching system by which the functions of each side of the body are able to gain access to the areas of specialization within each hemisphere." (Dimond, 1972)

Investigations into hemispheric brain process with normal persons of particular relevance to education have frequently utilized three techniques: dichotic listening, tachistocopic presentation and reaction time and electrosncophalographic measurement of the brain's electrical activity employing both frequency analysis and the evoked potential. The import of this accumulated research data is briefly discussed in the following sections.

Dichotic Listening

The dichotic listening technique involves presenting subjects with simultaneous auditory stimuli (one in each ear) and then measuring performance differentials. Because each hemisphere receives information primarily (though not exclusively) from the contralateral

ear, better left ear perception indicates right hemisphere superiority and vice versa.

Using this technique with normal right handed adults, the left hemisphere (right ear) has been found to better perceive and remember digits (Knox and Kimura, 1970; Kimura, 1961, 1967), both meaningful words and nonsense words that are easily pronounced (Curry, 1967), syntatic structure (Zurif and Sait, 1978), judging which of two stimuli came first and fine temporal order judgments, i.e., Morse Code (Papcun, Krashen, Terbeck, Remington and Harshman, 1974) (Shankweiler and Studdert-Kennedy, 1967), while the right hemisphere (left ear) is superior in perceiving and remembering melodies (Kimura, 1964), pitch perception (Halperin, Nachshon and Carmon, 1973), sonar signals (Chaney and Webster, 1966), environmental sounds (Curry, 1967), vocal nonspeech sounds, i.e., coughing, laughing and crying (Knox and Kimura, 1970; Kimura, 1973), and intonation contours used to indicate commands questions and declarative sentences (Blumstein and Cooper, 1974).

Visual Hemifield Studies

Consistent with left-hemisphere mediation in the processing of verbal, and right-hemisphere of nonverbal information, Mishkin and Forgays (1952) provided one of the first experimental proofs of more successful recognition of English words from tachistoscopic presentations to the right visual field (left hemisphere) relative to the left. These results were confirmed by Kimura (1967) and White (1974) using letter identification. Hines and Satz (1974) demonstrated superior

recall for digits presented to the right visual field, relative to the left. Marcel, Katz, and Smith (1974) extended the right visual field superiority for single letter recognition to seven-and-eight-year-old children.

Egeth (1971) notes that these right visual field linguistic superiorities have been detected in spite of the learned left-to-right reading habits of American students. Broadbent (1974) and Hines and Satz (1974) conclude that both habitual scanning patterns and relative hemisphere efficiency affect visual field differences. White (1969) summarizes that random bilateral presentations elicit a left field superiority. Mackavay, Curcie and Rosen (1973) report results which maintain right visual field superiority in word recognition.

In contrast to the results from linguistic displays, McGlone and Davidson (1973), Kimura (1966, 1969) report a left visual field (right hemisphere) superiority in dot enumeration tasks. Utilizing dot stereo-grams, Kimura and Durnford (1974); Durnford and Kimura (1971) determined that, although binocular viewing was necessary to elicit the effect, the right hemisphere was also superior in depth perception.

Yin (1970) suggests a right-hemisphere "predilliction" for recognizing faces, and Gilbert and Bakan (1973) found that nonverbal material, requiring spatial analysis, storage and recall, and gestalt synthesis, is more accurately processed by normal subjects in the right cerebral hemisphere.

Filbey and Gazzaniga (1969) and Gibson et. al. (1970) examined verbal response to the presentation of stimuli and found reaction time significantly shorter when information was presented to the right visual field, and hence directly to the hemispheric speech motor mechanisms necessary for output.

EEG Studies

Intrahemispheric processing is more efficient than that which involves interhemispheric communication, although Kleinman and Little (1973) have suggested that interhemispheric efficiency is dependent on the material to be processed. Dimond and Beaumont (1974) suggest that hemisphere integration occurs only after intrahemispheric processing of visually presented material. Greater output can be elicited, therefore, from a paradigm enabling both halves of the brain to be directly engaged. (Dimond, 1972) Dimond and Beaumont (1974) concluded that bilaterally specialized information management is adaptive in increasing creative and productive output. Using an electroencephlograph (EEG) to measure asymmetrical electrical activity in the cerebral hemispheres, lateralization of cortical functioning has been found. The left hemisphere processes most of the language functioning (overt and covert) as well as analytical and propositional thinking. The left hemisphere is active when overtly or covertly processing verbal material (Buchsbaum and Fedio, 1969; Wood, Goff and Day, 1971; McAdam and Whittaker, 1971; Morgan, McDonald and MacDonald, 1971; McKee, Humphrey and McAdam, 1971; Galin and Ornstein, 1972, 1974; Doyle, Ornstein and Galin, 1973), logical tasks (Dilling, 1975; Morgan, McDonald

and Hilgard, 1974; Butler and Glass, 1974) and mathematical computation (Butler and Glass, 1974; Morgan, McDonald and MacDonald, 1971) while the right hemisphere exhibits more activity during visuo-spatial tasks (Morrell and Salamy, 1971; Galin and Ornstein, 1972, 1974; Doyle, Ornstein and Galin, 1973), imaging various scenes (Morgan, McDonald and MacDonald, 1971) and musical activity (Doyle, Ornstein and Galin, 1973; McKee, Humphrey and MacDonald, 1971).

Sources of Individuality in Brain Functioning

Much of the research described in the preceding paragraphs is oriented to a normative approach to neurological processing. But, perhaps the most salient feature emerging from hemispheric brain research is a clearer elucidation and documentation of the concept of individual variability.

Ounsted and Taylor (1975) in summarizing current research in sex differences state that language lateralization tends to be diffuse (stored and processed in both hemispheres) in women with a greater degree of lateralization (stored and processed mainly in the left, analytic hemisphere) in men. Furthermore, Kirschner (1974) citing research on men and women with mixed hand eye dominance postulates that within the normal population individuals will be found with diffuse right hemisphere lateralization which interferes with their verbal abilities. Sex differences have been observed consistently in rod and frame measures of (FDI) cognitive style with males showing superiority in field independence, which has been associated with proprioception

and is believed to have visuo-spatial, right hemisphere process emphases.

Another population which has been cited as having diffuse lateralization are left handers (Levy, 1969; Miller, 1971) which lead to lower performance IQ's on the W.A.I.S. although verbal IQ's between dextrals and sinistrals are similar. Levy (1974) postulates that diffuse lateralization causes deficiencies in visuo-spatial and perceptual abilities because the language processing takes priority.

Galin (1975) states that difficulties arise not only from a failure to develop lateral specialization but also from individual or cultural differences in preferred cognitive style. Studies by Cohen (1969) and Bogen, et. al., (1972) have indicated that subculture may be characterized by emphasis on a predominant cognitive mode: the middle class employ a verbal-analytical mode and the urban poor are more likely to utilize a spatial synthetic mode.

Individual differences have been treated in three hypotheses regarding the relationship of hemispheric processes to cognitive style (field dependence - independence). Levy (1969, 1974), suggests that bilateral of diffuse representation of verbal and visuo-spatial capacities would result in interference and lower performance on lateralized tasks. Research wich sinistrals, having more diffuse bilateral representation of language is cited to support this position. The higher incidence of dyslexia in sinistrals (compared with dextrals) is attributed to this hypothesis. Inferring from limited data, Buffery and

Gray (1972) propose diffuse bilaterality as efficacious. Cohen et. al. (1973) has attempted to relate field dependence to left hemisphere laterality. After reviewing other hypotheses, O'Keefe (1975) has proposed an alternative "accers" hypothesis —

> An alternative hypothesis to the three discussed above is that field independent cognitive functioning and visuo-spatial abilities in general are more efficiently served by right-hemisphere cerebral mechanisms. It is proposed that "analytical" (in Witkin's terms) psychological differentiation (i.e., field independence) represents an ability to activate right-hemisphere neural substrates, concurrent with deactivation in the left. It is also suggested that this relative access to right-hemisphere mechanisms is determined at least in part by cognitive habits acquired during development.

Although signs of cerebral lateralization have been found in infants (Molfese, 1973); Gardner, Schulman and Walter, 1973; Witelson and Pallie, 1973) full lateralization does not occur until later childhood. (Krashen, 1975; Krashen and Harshman, 1972; Krashen, 1973; Dorman and Geffner, 1974; Berlin, et. al., 1973) and may continue to develop into senescence (Brown and Jaffee, 1975).

Gazzaniga (1974) postulates that because the yound child has extremely poor interhemispheric communication (Yacalev and Lacours, 1966), he operates as a functional "split-brain" until the age of two, processing experience in each hemisphere with little specialization. Harris (1973) and Knox and Kimura (1970) suggest that the right hemisphere modality is dominated in the spatial orientation of young children's behavior. This pattern slowly changes as language is acquired to a left hemisphere orientation, which is attributed to be partly a result of schooling (Bogen, 1975). Bogen suggests educational neglect

of right hemisphere cognitive potential which is "as important (or high-level problem solving) as language skills" (p. 30) and necessary, though not sufficient, for creative thinking (Bogen and Bogen, 1969).

Thus we have completed a critical appraisal of an educational perspective on the hemispheric process of the brain—historical conceptions of the dualism in man's ways of knowing, biological mechanisms of learning and the emerging body of research in hemisphere brain process. From these considerations, we can conclude that within the hemispheric brain process and the concerns of education lie broad areas of common interest and relevance.

Directions for Research

In the final section of this article, we shall recommend directions for the educational applications of hemispheric brain function in six areas of research for early childhood and elementary school.

1. Educational measurement

Measurement involves defining things to be counted. Definition arises from perceiving attributes directly or from their effects. In education we characteristically assume the relationship between effects and attributes. For example, as Rentel (1975) has observed, there is an assumed relationship between the trait, comprehension, and many measures of reading as students respond to recall questions over passages read. Again, there is an assumed relationship between the trait, problem solving, and measures in science and social studies as students respond to multiple choice items from a problem context presented to

them. Measurement error from these assumptions may be of a substantial dimension as is clearly indicated by the fact that we have not made physiological measurements (including brain functioning) during the students' performance on existing paper and pencil measures nor have we ever begun to utilize neuro-physiological assessment to define with more precision and validity the attributes we claim to represent as basic and essential outcomes of educational practice. In this context measurement of neural mechanisms and learning should provide a more comprehensive and vaild understanding of the nature of learning. There is, therefore, a need for interdisciplinary research to reduce measurement error in constructs of measurement theory, instruments and practice through correlation of educational measures with neuro-physiological mechanisms of learning.

2. Curriculum

Curriculum denotes one of two basic elements defining the domain of education. The major research area in applying hemispheric function to school curriculum is task analysis. What are the neuro-physiological parameters of learning tasks in the school curriculum? Curriculum task analysis will be best served through research that focuses upon the bilateral conception of brain function and the interaction of hemispheric modalities in task solutions. For example, in the curriculum area of children's literature, both modalities are inferred in the basic parameters by which qualitative judgments are made for the annual Caldecott award, namely the integration of the illustrations

(visuo-spatial) with the text (verbal). Moffett reflects upon the integration of hemispheric modalities in discussing the role of the visual metaphor in literature (Sohn, 1975). In considering instructional aspects of curriculum assessment, this approach clearly relates to the research of Paivio (1971, 1973) and Wittrock (1975) in utilizing imagery in instruction.

Neurophysiological task analysis of "hands-on" curriculum orientation of contemporary elementary science curricula may provide further insights into two consistent research findings in the existing science education research literature: In classrooms utilizing contemporary science curricula, achievement of inner-city students (characteristically much lower in educational performance) equals their suburban peers; there is an increase in students' language skills associated with these curricula (Languis and Kraft, 1976; Huff and Languis, 1973).

Inquiry competence is highly valued as a curriculum and instructional goal (Rowe, 1978). Assessment of inquiry oriented curricular tasks and instructional strategies through neuro-physiological measurement to elucidate the nature of inquiry behavior both the for learner and the teacher would be a complex and difficult but important research arena.

Analysis of the expressive arts through hemispheric research paradigms is suggested as an example when the nature of the task probably does matter (Bogen, 1975).

The field of media in educational context might well be approached

through the interaction model of hemispheric processing with some attention to the insights of McLuhan along these lines.

In assessing curriculum for early childhood programs the developmental parameters of hemispheric specialization may provide clues for research directions. Harris (1973) summarized a group of studies strongly suggesting right hemisphere dominance during infancy and a neuroanatomical disposition for spatial learning.

Finally, Bogen (1975), Ornstein and Galin (1975), suggest that the entire school curriculum and indeed American culture may be inordinately skewed to reward left hemisphere modality. "...an elementary school program narrowly restricted to reading, writing and arithmetic will educate mainly one hemisphere leaving half of an individual's high level potential unschooled...Just as left hemisphere potential for propositionizing may be underdeveloped, so too should we expect that right hemisphere capacities can suffer from educational neglect... If our society has overemphasized propositionally at the expense of appositionality more is involved than the adjustment of isolated individuals. It means that the whole student body is being educated lopsidedly." (Bogen, 1975, pp. 27-29) It will be noted that the direction for research proposed in this article is focused upon task analysis and correlation with neurological processes. From such an effort a better balance may be achieved in teaching within a given curriculum area as well as across the entire school program.

3. Instruction

Instruction is the other basic area in the educational domain. Research in this area will probably be very fruitful for education as "hemispheric specialization tends to be process specific rather than material specific (which) suggests that subject matter may be less important than method of presentaion" (Bogen, 1975, p. 30).

The basic problems in instruction relate to instructional presentation mode by the teacher, response mode required of the student and application of dual trace theory in memory and instruction. There is evidence that learning and memory is enhanced by presenting subject matter in such a way that both hemispheres participate (Bower, 1972; Seaman, 1972; Dimond, 1972) and that it is possible to challenge either hemisphere or both hemispheres by varying the coding strategy (Seaman and Gazzaniga, 1973).

Merle Wittrock (1975) at UCLA suggests that the classroom teacher should first, assess the individual's learning mode, then prescribe primary instruction techniques; those which would directly challenge the individual's preferred hemispheric mode (or the task) while supplementing this instruction with secondary instruction techniques which are designed to encourage the other hemisphere to participate in the activity.

Some of the research goals which are suggested would include: finding a reliable measure of an individual's unique cognitive mode of learning; defining and designing instructional technique which would challenge one or the other hemispheric mode specifically and

supplementary techniques to encourage participation of the other hemisphere; setting parameters which vary response modes as well as instructional modes which will best match and/or challenge the individual's cognitive mode; determining some tasks that are hemisphere specific which may imply that mutual participation of both hemispheres would be inefficient and perhaps detrimental (Levy, 1972).

Kraft (1976) conducted an EEG study with second grade children while they performed Piagetian and school related curriculum tasks, involving presentation-response mode assessment. In collaboration with Professors Wheatley and Mitchell at Purdue University EEG assessment was made of alpha power ratios from homologous leads ($P_3 - P_4$). Hemispheric brain processing in spatial tasks was investigated comparing mental imagery and analytic solution modalities and Piagetian task performance was compared with and without perceptual screening (Bruner, 1966). In one task, a shift from right to left hemisphere brain activity across subjects was observed when the task was first presented visuo-spatially and then was presented behind a screen accompanied by a verbal description. Kraft also found that children who were successful (conservor) on Piagetian tasks displayed brain functioning patterns suggesting integration of the two hemispheres.

4. Interaction and Communication

Communication in the home or classroom results from verbal and nonverbal behavior. Elaborate coding mechanisms for investigating

verbal classroom interaction have been employed (Flanders, 1960, Hough and Duncan, 1965). Recently much attention has been given to the impact of nonverbal behavior, in classroom communication. Galloway (1968, 1971) has extensively delineated nonverbal communication in the educational domain. Kock (1971), and Victorial (1971) found that when verbal and nonverbal cues are not congruent, the nonverbal information is usually believed by the child. Woolfolk and Woolfolk (1974) supported this finding. It is well established that right hemisphere modality is superior at facial recognition and general spatial, nonverbal cues while left hemispheric process has the edge in verbal communication. Galin (1974) has extensively conceptualized and documented the immediate and long-range psychiatric implications of congruence and conflict in verbal and nonverbal information fed to the two hemispheres. What are the implications for both the adult and the child when a parent or teacher communicates verbally "I approve," but simultaneoulsy communicates non-verbally, "I disapprove." Areas of importance to educators regarding verbal and nonverbal behavior and the brain hemispheres relate to assessing the interaction of physiological mechanisms including the autonomic nervous system and the brain hemispheres with verbal-nonverbal experience. Within this context, investigations of source of stress, distress and the optimal reduction of stress and individual differences in stress response, are indicated (Corson, 1976; Sandman, 1975).

A substantial problem in nonverbal educational research has been

adequate measures at reliability and validity regarding normative meaning in nonverbal behavior (Galloway, 1971), but for the individual there may be substantial contextual consistency in interpreting nonverbal behavior. Thus an area of educational interest in nonverbal communication would be measurement error reduction and individuality.

An investigation relating the interaction of verbal and nonverbal information and hemisphere process was conducted by Rice (1977). Error and reaction time responses of elementary school children were assessed during right and left use of hemifield tachistoscopic presentations of nonverbal cues that matched or mismatched a verbally induced set. Subject's responses to right hemisphere presentation were faster and more accurate than those presented to the left.

5. Learning Problems

Geschwind(1972) recently pointed out "one must remember that practically all of us have a significant number of learning disabilities... we happen to live in a society where the child who has trouble learning to read is in difficulty. Yet we have all seen some dyslexic children who draw much better than 'normal children', i.e., who have either superior visual perception or visual-motor skills," In another setting these children might excel. Therefore as the demands of our society change we may label a new group of persons "minimally brain-damaged". Guyer and Friedman(1975) found that learning-disabled children were not deficient in right hemisphere skills nor were they deficient in all aspects of verbal ability when compared with normals.

They seemed to be attempting to use a nonverbal modality to solve academic tasks.

Also, the lack of success we have with many children--frequently boys--in teaching the basic "verbal" skills of reading and writing which are clearly the "passports" to success in American schools today suggests that we need to draw on our knowledge about nonverbal representational systems to aid us in developing verbal representational systems.

There is a continuing need to utilize the assessment of neurological brain functioning patterns in the diagnosis of learning problems children experience in the normal classroom situation.

Therefore, the basic research questions relevant to learning problems focus upon diagnosing the mismatch of the individual's neurological processing propensities with instructional and curricular expectations of parents and teachers, followed by attempts to facilitate adaptive behavior in the child and the school establishment.

6. Individuality

Providing for individual differences has traditionally been a central aim of educators (NSSE Yearbook, 1962). Kagan and Kagan (1972) exhaustively review cognitive style research and literature with respect to individuality. Cognitive style referes to relatively stable and reliable individual preferences in mode or pattern of processing information (Kagan, Moss and Siegel, 1973). Witkin (1962) points out that cognitive style is imbedded in a personal life and its development

in a personal history suggesting the utility of developmental research of these self-consistent modes of functioning.

A beginning has been made in establishing the relationship of cognitive style to hemispheric brain process as indicated earlier in the literature review. The importance of this relationship is suggested by leading brain researchers (Ornstein and Galin, 1975; Bogen et. al., 1972). A clear need exists to investigate the dimensions of cognitive style and neurological processes more completely. The continued use of one cognitive mode would result in a "cognitive style that would pervade most task operations and should be detectable as a deficit where task requirements and cognitive style are incompatible" (Guyer and Friedman, 1975, p. 658). Cognitive style should be observable both in teaching and learning style. Does the teaching style of a specific teacher challenge one learner with his individual cognitive mode and frustrate another?

Other parameters of individual variation reviewed earlier have been clearly related to brain function. These sources of variation include: gender, developmental level, handedness, patterns of neurological organization, membership in American subcultures and socioeconomic class (Bogen, et. al., 1972) and environmental deprivation. That environmental deprivation may slow down the normal course in the development of lateralization has been suggested by Geffner and Hochberg (1972). Therefore the relevant emphasis for research regarding individuality is to recognize the sources of individual variation in

assupmtions made and in the design of investigations in all the arenas recommended.

This approach should facilitate both the building of an authentic research data base from which more general statements may eventuate and an approach to learning and learning problems that fosters learner self-determination.

Summary

Analysis of three elements in an educational perspective on psychobiological dimensions of learning and the hemispheric process of the brain indicates substantive areas of common interest. The elements reviewed were historical views of man's intelligence, biological roots of behavior and empirical findings regarding brain function.

Six areas have been proposed as directions for interdisciplinary research relating educational concerns in young children (early childhood and elementary school) and the psychobiological dimensions of learning and learning problems with special emphasis on hemispheric brain process:

1. Reduction of measurement error in educational assessment;
2. Task analysis in educational curriculum;
3. Instructional assessment emphasizing variation in presentation mode by the teacher, response mode of the student, cognitive information processing and memory, including imagery;
4. Verbal-nonverbal behavior and stress in classroom communication in curriculum-instruction interaction;

5. Psychobiological dimensions of learning problems;

6. Sources and assessment of individual variability.

Table One

Author	Modes of Knowing	
Bogen	propositional	appositional
Bruner	rational	metaphoric
Cohen	analytic	relational
Hilgard	realistic	impulsive
Humphrey and Zangwill	propositional	imaginative
W. James	differential	existential
Kagan and Moss	analytic	relational
Levy and Sperry	analytic	Gestalt
Maslow	rational	intuitive
Neisser	sequential	multiple
Ornstein	analytic	holistic
Piaget	operative	figurative
Schopenhauer	objective	subjective
Sechenov (per Luria)	successive	simultaneous

A partial list of authors who have postulated two "ways of knowing" or two "types of intelligence" or two "cognitive styles".

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